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AUTHOR Poltz, Ross
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ABSTRACT

This booklet, one of a series developed by the Frederick County Board of Education, Frederick, Maryland, provides an instruction module for an individualized or flexible approach to secondary science teaching. Subjects and activities in this series of booklets are designed to supplement a basic curriculum or to form a total curriculum, and relate to practical process oriented science instruction rather than theory or module building. Included in each booklet is a student section with an introduction, performance objectives, and science activities which can be performed individually or as a class, and a teacher section containing notes on the science activities, resource lists, and references. This booklet introduces the student to the chemistry of water. The estimated time for completing the activities in this module is 2-3 weeks. (SL)

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Water AIDS TO INDIVIDUALIZE THE TEACHING OF SCIENCE

ED130896

U.S. DEPARTMENT OF HEALTH,
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MINI-COURSE UNITS

BOARD OF EDUCATION OF FREDERICK COUNTY

1974

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WATER

Prepared by
Ross Foltz

Estimated Time for Completion

2 to 3 weeks

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Mini Courses for

Physical Science, Biology, Science Survey,
Chemistry and Physics

Committee Members

Physical Science	-	Marvin Blickenstaff Charles Buffington Beverly Stonestreet Jane Tritt
Biology	-	Paul Cook Janet Owens Sharon Sheffield
Science Survey	-	John Fradiska John Geist
Chemistry	-	Ross Foltz
Physics	-	Walt Brilhart

Dr. Alfred Thackston, Jr.
Assistant Superintendent for Instruction

Marvin Spencer
Supervisor of Science

Frederick, Maryland

1974

THE FORD

The writing of these instructional units represents Phase II of our science curriculum mini-course development. In Phase I, modules were written that involved the junior high disciplines, life, earth and physical science. Phase II involves senior high physical science, biology, chemistry, physics and science survey.

The rationale used in the selection of topics was to identify instructional areas somewhat difficult to teach and where limited resources exist. Efforts were made by the writers of the mini-courses to relate their subject to the practical, real world rather than deal primarily in theory and model building.

It is anticipated that a teacher could use these modules as a supplement to a basic curriculum that has already been outlined, or they could almost be used to make up a total curriculum for the entire year in a couple of disciplines. It is expected that the approach used by teachers will vary from school to school. Some may wish to use them to individualize instruction, while others may prefer to use an even-front approach.

Primarily, I hope these courses will help facilitate more process (hands on) oriented science instruction. Science teachers have at their disposal many "props" in the form of equipment and materials to help them make their instructional program real and interesting. You would be remiss not to take advantage of these aids.

It probably should be noted that one of our courses formerly called senior high physical science, has been changed to science survey. The intent being to broaden the content base and use a multi-discipline approach that involves the life, earth and physical sciences. It is recommended that relevant topics be identified within this broad domain that will result in a meaningful, high interest course for the non-academic student.

ALFRED THACKSTON, JR.
Assistant Superintendent for Instruction

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WATER

A. Importance of Water

It is everywhere around us. Water in its many forms covers three quarters of the surface of the earth. It is found above the earth as a gas, liquid or a solid. It percolates and filters through the soil and rocks beneath the earth.

Wars have been fought by men who needed more water, and wars have ended when water rights were decided. Great cities have developed near water and great civilizations have died when there was no longer an ample supply.

Water is massive oceans which can supply food, provide transportation, and control climate. It is grinding ice fields which have continued to shape and reshape the surface of the planet down through the ages. It is winding rivers which act as lifelines for men who dare to move inland from the seas. It is tides, waves, hail, raindrops, bays, ice, steam, puddles, lakes, ponds, and streams.

Water differs from most liquids. Water expands and becomes less dense as it freezes while most other liquids contract and become more dense. The solid form of water (ice) floats in the liquid form.

Water comes close to being the "Universal solvent". A solvent is a substance, usually a liquid, which dissolves other substances. Water is such a powerful solvent that it is difficult, if not impossible, to find "pure" water in nature.

Pure water does not conduct electricity. However, when even a small amount of a substance such as acid, base or common salt is added that will form ions on dissolving, water becomes an effective conductor of electricity.

We must drink a large amount of water each day in order to maintain life and health. Seventy percent of the weight of our bodies is water. We can lose up to 3 gallons of water each day through perspiration and liquid waste. If the water we lose from our bodies is not replaced, we will eventually die. Man can live for 5 weeks without food, but can live without water for only about 5 days.

A large amount of water is required to grow the food which we eat. Without an adequate supply of water, we could not feed our population.

We depend on water for washing. Without water we might be forced to live in dirty, disease-ridden, undesirable surroundings. In many ways, our lives and health depend on our being able to wash.

An enormous water supply is required in order to maintain business and industry. It is no accident that most industries locate their plants near large, dependable water supplies. Water in abundance is required for power, cleaning, cooling and transport.

We use water for recreation. Our lives are enriched and made more enjoyable by such sports as fishing, swimming and boating.

Water has a remarkable ability to purify itself. Some pollutants are bleached out by the sunlight; some waste products will settle to the bottom of the water and remain there; some contaminants are consumed by bacteria found in the water; some contaminants are made harmless when diluted by fresh water, and some contaminants are destroyed by oxidation.

Water absorbs oxygen from the air and from water plants. This dissolved oxygen combines with some organic waste directly; thus, the organic wastes are chemically burned leaving behind carbon dioxide, water and ash. Dissolved oxygen is a vital requirement for purification of water.

Thoughtlessly, we have given our water resources a bad case of "indigestion". We have overloaded our lakes, rivers, and bays and the natural purification processes cannot keep up - as the load of pollution has increased, the number of bacteria in the water has also increased. Bacteria, which require oxygen for survival, eventually use most of the dissolved oxygen in the water. Thus, rivers and lakes near large cities and factories eventually become "sick" and unable to provide an environment where fish and vegetation can survive. No longer life-giving arteries, some rivers have become ugly smelly sewers.

We face a serious pure or useable water shortage. The amount of water on the earth remains about the same, but due to the pollution of our present supply, along with an increase in demand, this shortage becomes very apparent and near - the demand for water is expected to double by the end of this century.

We are faced with the problem of developing better, less expensive and much larger facilities for taking our present polluted water supplies and making them reuseable (potable) for our world of today.

The most sensible water treatment would be treatment which allows water to be reused many times without entering the rivers and streams. If better treatment methods were developed, water used in factories, homes, and businesses for cooling and cleaning, drinking, and other such uses, could be recycled back into the water supply many times for reuse.

B. Composition of Water

Although water is a very common substance, pure water is not common. What do we mean when we speak of pure water? If we were to ask an average citizen, a chemist, and a biologist what they meant by pure water, they each would have a different standard.

The citizen would call water pure if it is suitable for drinking. Water that is fit to drink is called potable water. It must be clear and colorless, pleasant tasting, free of harmful bacteria and fairly free of dissolved minerals.

Pure water for the chemist is water that is free of all minerals and dissolved gases. This can be obtained by distillation or ion exchange method.

Pure water for the biologist must meet the requirement of the chemist and also must be free of all living bacteria or organisms; sterilizing distilled water makes this possible.

OBJECTIVES

The student should be able to:

1. describe the chemical composition of water.
2. identify the elements that make up pure water.
3. describe how burning certain substances can produce water.

ACTIVITIES

a. Lab - Electrolysis of Water

This experiment will be done as a demonstration. From your observations, complete questions and conclusions on your worksheet #1.

Name..... Date..... Expt. No..... Teacher's Criticism.....

Electrolysis of Water

(This experiment may be performed as a demonstration.)

Introduction: A commercial method of obtaining large quantities of hydrogen and oxygen is by the electrolysis of water. *Electrolysis* is a reaction brought about by means of electrical energy. Since water by itself is a poor conductor of electricity, a few drops of sulfuric acid are added to the water to increase its conductivity. Such a substance is called an *electrolyte*. Platinum electrodes are used because platinum will not react with the acid, nor with the oxygen or hydrogen.

Purpose: To decompose water into its elements, oxygen and hydrogen, by means of an electric current.

Apparatus: Electrolysis apparatus (either as in figure A, or the Hoffman type in figure B), source of direct current of 6 to 8 volts (4 to 6 dry cells in series, a 6-volt storage battery or a 110-volt direct current source with a 60-watt lamp in series), Bunsen burner, stirring rod, ring stand, clamp, connecting wires.

Materials: Water with a small amount of sulfuric acid added, making the mixture about 1:20; wood splint.

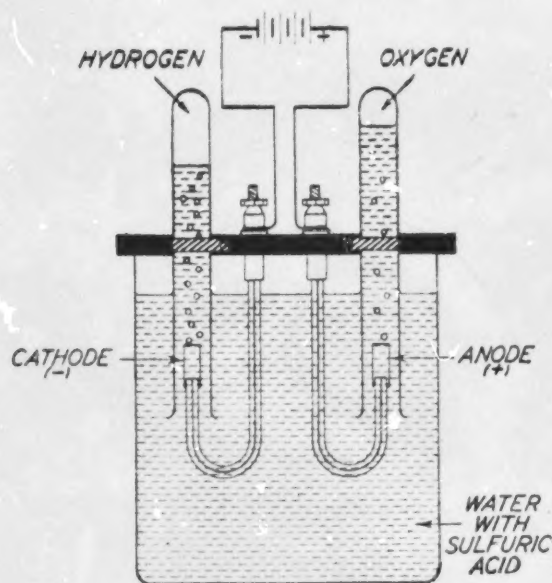


Figure A

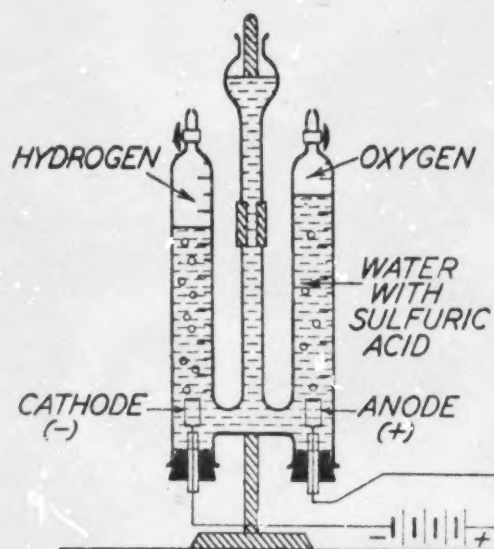


Figure B

Word Equation:

Procedure and Observations:

If you are using the apparatus shown in figure A, fill the battery jar about two-thirds with water to which a little dilute sulfuric acid has been added. Also fill the two test tubes and invert them in the battery jar. (If you are using the Hoffman apparatus shown in figure B, fill the side tubes to the top and close the stopcocks.) Connect the platinum

electrodes to the source of direct current and turn on the current. The electrode connected to the positive terminal of the source is the anode (+), and the electrode connected to the negative terminal is the cathode (-).

1. Describe what happens at the electrodes.
2. At the (anode, cathode), the gas collects twice as fast as the gas at the
3. The gases collecting at both electrodes are (color).

When the gas collecting at the cathode completely fills the test tube, place your thumb over the mouth of the tube and remove the tube from the battery jar. Bring a burning splint to the mouth of the tube. (In the Hoffman apparatus, collect 50 c.c. of gas at the cathode and open the stopcock, holding a burning splint at the outlet.)

4. Result:
5. The gas collected at the cathode is

When the gas at the anode fills the tube (or when 50 c.c. have collected in the Hoffman apparatus), test the gas with a glowing splint.

6. Result:
7. The gas collected at the anode is

Conclusions and Related Questions:

1. The experiment shows that the composition of water by volume is volume(s) of hydrogen to volume(s) of oxygen.
2. water (electrolyzed) $\rightarrow$ $\uparrow$ + ... $\uparrow$
3. The composition of water by weight is part(s) of oxygen to part(s) of hydrogen.
4. The sulfuric acid was mixed with the water for the purpose of
5. Is the sulfuric acid used up in this experiment?
6. Name one industrial use of the electrolysis of water.

Student's Diagram:

b. Lab - Water is a Product of Burning

Use Physical Science by Lemkin - Oxford Book Company, page 54.

Do experiment demonstrating that water is produced when certain substances burn and answer questions in the experiment.

C. Properties of Water

Pure water is a colorless, odorless, and tasteless liquid. From experience, we have seen that it exists as a solid, liquid and gaseous phase, its energy level determining the phase. On the centigrade thermometer (which is used by the scientists and by most of the world) water freezes at 0°C and boils at 100°C .

In many ways water is a most remarkable substance. Almost all liquids shrink when they freeze. Water is the only common liquid that expands as it freezes. When a tankful of water freezes, up to 15 tons of force press out on each square inch of the tank. Water pipes and automobile radiators burst in winter when water in them freezes.

When water at 0°C is warmed, it contracts until its temperature reaches 4°C . Then, as the temperature is raised further, the water gradually expands. At the temperature of 4°C , water reaches its greatest density.

Chemically, water is a very stable compound. It does not break up into hydrogen and oxygen until its temperature reaches about 2700°C . This property makes it an important chemical solvent.

OBJECTIVES

The student will be able to:

4. describe some common physical properties of water.
5. relate physical properties of evaporation and condensation to the water cycle.
6. describe how water reaches its greatest density at 4°C .
7. describe why water is a polar molecule.
8. describe why water is a good solvent.
9. list and illustrate by example the factors that affect solubility.
10. demonstrate a concentrated and a dilute solution.

ACTIVITIES

a. Let's Do Some Reading for Information:

1. Physical Science, Lemkin, Oxford Book Company, pages 51-53
2. Modern Physical Science, Tracy, Holt, Rinehart & Winston, pages 148-152
3. Everyday Facts about Good Water, Manufacturing Chemists Assoc.

This information will help in the following activities.

b. Lab - Demonstrating the Water Cycle

Carry out the activity as directed on page 52 in Physical Science, Lemkin, Oxford Book Company. Answer the question that is Part 2 of this experiment.

c. Film - 239, Chemistry of Water

Film will be provided by teacher.

Questions to discuss -

- (1) What is a polar molecule?
- (2) How does water molecules make hydrogen bonds?
- (3) Show arrangement of the water molecule by drawing.
- (4) Why is water a good solvent?
- (5) At what temperature does water have its greatest density? why?

d. Bulletin Board Project - Water and Its Treatment

Now that you have begun to learn about water, read your local newspapers, current magazines and follow up any stories you can find about water, its use and its treatment. Place information on the bulletin board.

e. Demonstrating some Characteristics of Solutions

1. Fill 4 test tubes $\frac{3}{4}$ full of water and arrange them in a test tube rack. Drop two crystals of potassium permanganate (KMnO_4) in the first test tube and shake the tube until the crystals are completely dissolved. Add increasing amounts of the same chemical to the other three tubes and shake as before.
 - (a) Is each solution uniformly colored?
 - (b) Explain the light pink to deep purple variation of colors.
 - (c) How does this demonstration illustrate the difference between dilute and concentrated solutions?
2. Weight out 5 grams of some common household materials, such as salt, baking soda, sugar, Epsom salt. Place each substance in a test tube, and put all the tubes in a test tube rack. Add water to each, a little at a time. Shake the test tube vigorously after each addition, until all the solution is dissolved. With a graduated cylinder, measure the final volume of each solution. Record results.
 - (a) Which material has the greatest solubility?
 - (b) What do you conclude from this data?

f. Lab - Factors Affecting Solubility

1. Place 5 grams of CuSO_4 copper sulfate in two 250 ml beakers. Half fill each beaker with water. Stir one beaker, but not the other. Which beaker does the copper sulfate dissolve faster?
2. Place one lump of copper sulfate (approximately 5 grams) in a beaker. Grind another lump of equal size in a mortar, and place the ground copper sulfate in a second beaker. Half fill each beaker with water. Stir both beakers. In which does the copper sulfate dissolve faster?
3. Place 5 grams of copper sulfate in two beakers. Half fill one beaker with hot water and the other with cold water. Stir both beakers. In which does the copper sulfate dissolve faster?

D. Impurities of Water

Water always contains impurities, but not all impurities are harmful. The water you drink contains several kinds of minerals. For example, hard water is the term used for water which contains too much calcium or magnesium. Other impurities are also present, such as chlorine which is added to drinking water to kill bacteria. In the following activities you will be identifying some of the most common impurities found in drinking water.

OBJECTIVES

The student will be able to:

11. describe ways that common impurities in water can be detected and identified.
12. demonstrate a method of measuring the relative hardness of different sources of water.
13. explain why the presence of ammonia might indicate organic matter contamination.

ACTIVITIES

- a. Lab - How can impurities such as chlorine, sulfates and organic matter be detected?

1. The directions for this investigation are contained in Laboratory Investigations for Modern Physical Science, Tracy, Holt, Rinehart & Winston. Carry out Investigation 13.2 and 13.3, pages 42-43. Answer the questions following these activities.

- b. Lab - Test for Water Hardness

Hard water is water that precipitates or curdles soap. The term "hard" means it is hard to make suds with. Clothes may not be properly cleaned in hard water. The precipitate or curd that forms leaves a greasy film on the fabric and gives it a dingy appearance. Distilled water is free of hardness and is called soft water. Hardness in water is caused by dissolved calcium and magnesium compounds in the water.

1. The purpose of this lab is to compare various samples of water in terms of hardness.

Materials - baby food jars with covers, standard soap solution (liquid soap diluted with isopropyl alcohol), medicine droppers, water samples including distilled water

Procedures:

1. Make a mark on the food jar about three-fourths from the bottom. Start with distilled water first. Fill the food jar to the mark. Add three drops of soap solution. Shake the mixture and watch for suds. If a suds form, find out if it will remain for 20 seconds. If not, add three more drops of soap solution. Shake and again watch for the formation of suds. Continue until suds that stay for at least 20 seconds form. Count the total number of drops of soap solution used. When distilled water is used, probably 5 or 6 drops will be enough. When this number of drops is determined, subtract it from the number of drops used in each of the following water samples. This is called the suds factor.
2. In place of the distilled water, use a sample of water to be investigated. Place it in the empty, clean, and rinsed jar up to the mark. Add soap solution as before, shaking after each three drops addition. Count the number of drops of soap solution needed to make a suds that lasts for 20 seconds. Subtract the number for distilled water (suds factor) found in part one.
3. Continue with other water samples. Report each finding as indicated below.

Record

The record of hardness test can be made in tabular form.

Sample	Drops of soap sol.	Suds Factor	Net Number of drops
Distilled H ₂ O suds factor	6	6	0
Faucet water	18	6	12
Well water	30	6	24
Creek or brook water	21	6	15

From the table, the relative hardness of the samples are shown.

c. Lab - Measurement of the pH Value of Water. (Extra Credit)

What do you predict will be the pH (acid or base) values of some of the following types of water that you come in contact with in your daily living: the water you drink; water in the fish bowl; water to which you add detergent for cleaning; rain water; water in the creek or river where you boat or fish; water in your swimming pool, etc? If the answer to this question interests you, you may do some research.

The directions for this project are found on pages 41-43 of Environmental Pollution by Weaver, published by Holt, Rinehart & Winston.

d. Lab - How Acid is the Rain? (Extra Credit)

What effects do the contaminants in the air have on the rain in your locality? Does it make it acid? If so, how acid? Is it acid enough to affect marble buildings and statues? Where do the acid rains in rural areas come from?

1. To determine the rain's acidity, use a specially treated paper called Hydrion. The paper measures directly the pH of a sample of rain water. The lower the pH, the more acid the water sample. The Hydrion paper changed to a color based on the acidity of the water. By comparing the color change with a chart showing a range of acidity from 1 to 10, the exact pH can be determined.

To compare your results to that in the United States, see Current Science, Vol. 59, January 9, 1974.

E. Purification of Water

When the water vapor of the atmosphere condenses to form rain, snow, hail, sleet, and dew, the resulting liquid or solid is the purest form of water to be found in nature. After coming in contact with the air and the ground, water soon becomes contaminated by various impurities. These impurities include gases, bacteria, dissolved substances and finely divided solid matter in suspension.

Some of this foreign material is harmless to human beings; some of it may even be beneficial to us. Certain impurities, however, are harmful to health, and unsuitable for industrial use. These undesirable materials must be removed from the water in order to make it fit for human consumption and use by industry.

Several methods are commonly used to obtain pure water for use in home, community, factory, and laboratory.

Objectives

The student will be able to:

14. describe methods that can be used for making water suitable for drinking.
15. describe your present water supply, and tell the purification steps used.

Activities

- a. Do some research. (Read a book.)

References:

Physical Science, Lemkin, Oxford Book Company, pages 61-66
Modern Physical Science, Tracy, Holt, Rinehart & Winston,
pages 154-157

Answer:

- (1) List five steps commonly used for purifying city water. Explain each.
- (2) What chemicals are used to settle suspended particles in water? Explain their action.
- (3) Describe how a sand filter is used in purification of water.
- (4) Make a flow sheet showing the basic steps in water treatment.

b. Let's Take a Closer Look - Field Trip

1. Visit a water treating plant in your neighborhood.
2. Use the following questions as a study guide.
 - (a) List the basic steps that you observed in purifying water.
 - (b) Describe each step briefly.
 - (c) Does the local plant fluoride treat the water? Why?
 - (d) Make a flow sheet of the different processes used in water treatment. Describe the purpose of each briefly.

c. Lab - Coagulation and Sedimentation

If water contains suspended colloidal particles that require a long time to settle, coagulation is employed. The process of coagulation involves adding alum and a base, such as lime water, to the water to be clarified.

Procedure - Fill two 400 ml beakers with tap water and add one teaspoon of clay or Kaolin. Stir vigorously. Then add a little alum solution and a little lime water to one of the beakers and mix well. Now place both beakers on the table and examine them after a short time. Examine again later if necessary. If possible, let set overnight and observe the next day.

Answer questions.

1. In what beaker did the suspended particles of clay settle more completely in a shorter period of time?
2. Describe the process of coagulation.
3. Give the chemical equation for this reaction.
4. What happens to the lime water (Ca(OH)_2) and the alum ($\text{Al}_2(\text{SO}_4)_3$) in the purification process?

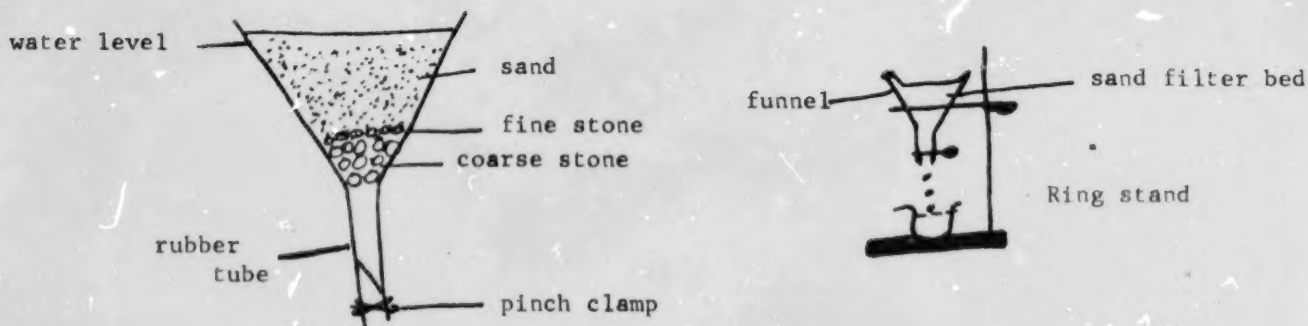
Save the clarified water for use in the sand filter.

d. Lab - Filtration

Water is allowed to pass slowly through layers of sand and gravel called filter beds. In this way, suspended impurities remaining from the coagulation and settling action are removed.

As shown in Figure 1 on the next page, fill a large funnel with layers of coarse stone, fine stone and sand. Support the funnel on a ring stand. Fill funnel carefully with tap water so as not to disturb sand and gravel layers.

Figure 1



Pour some of the water (from the settling process in Activity c) into the top of funnel allowing a small stream to flow from the funnel by regulation of pinch clamp on bottom of rubber tubing on the funnel. It is important to keep the water level above the top of sand layer at all times during this filtering operation. Check clarity of water from the funnel (filter bed). If not clear, pass through filter bed again.

Is this water, which should be very clear, safe to drink? Explain.

Save water collected in this experiment for lab experiment on chlorination.

e. Experiment - Chlorination

Chlorination is generally used to make sure that all harmful bacteria remaining in the filtered water are destroyed. A varying amount of chlorine is added to the water from the sand filters depending upon the condition of the water and the season of the year. In the fall more chlorine is used because more organic matter gets into the water. About three pounds of chlorine is added to one million gallons of water. This will kill algae and other low forms of animal and plant life, particularly bacteria.

1. Secure a bottle of Chlorox and from the label on the bottom determine the amount of Chlorox necessary to purify a given amount of water. Add this to the filtered (crystal clear) water. Should this water be safe for drinking? How should it taste?

f. Experiment - Deodorizing with Activated Carbon

1. Put 10 ml of H_2S solution in a test tube and add about $\frac{1}{2}$ teaspoon full of activated charcoal; stopper the test tube and shake vigorously. Set the test tube aside and shake it occasionally throughout the period. At the end of the period open the test tube and smell the mixture to see if the rotten egg odor (characteristic of hydrogen sulfide) is still present.

- g. Do some reading for information on ion exchange.

Modern Physical Science, Tracy, Holt, Rinehart & Winston, pps. 158-159
Water Pollution - Cause and Cures, "Ion Exchange", Manufacturing
Chemists Association

1. How does sodium zeolite soften water by the ion exchange method?
2. How is the zeolite unit made reusable?

- h. Viewing Film

Film 874 - A Town that Washes its Water

After viewing film, (1) list methods used to purify water; and
(2) list uses for which water of different degrees of purity
may be used.

- i. Lab - Purification of Water by Distillation

Carry out experiment and answer questions in the interpretations
as given by Exercises and Investigations for Modern Physical Science
by Friedl, Holt, Rinehart and Winston, Investigation 9-1, pages
45-46.

- j. Lab - Purification of Water by Ion Exchange

Run tap water through the Kleen Stream Water Filters (Ion Exchange
Softener supplied by the teacher) to remove minerals. The treated
water should be soft.

Using three marked test tubes or bottles, fill one $\frac{1}{2}$ full with
distilled water, another $\frac{1}{2}$ full with untreated tap water and the
third $\frac{1}{2}$ full of the treated water. Add soap solution, three drops
at a time until a suds remains 30 seconds upon shaking the bottle
or tube. Record the drops of soap solution required for each
sample.

Compare the amount of soap solution used in the distilled water with
the amount used in the untreated and treated tap water.

Does the treatment for the removal of the calcium ion (cause of water
hardness) seem to be effective by the ion exchange method?

F. Unit Review

Things to Explain

1. Give reasons why water is regarded as the most important compound on earth.
2. What elements, when burned, produce water?
3. About what proportions of all plant and animal matter consists of water?
4. What is the water cycle? Explain its operation.
5. A sample of water is colorless, odorless, clear and cool. Are we justified in assuming the water is safe to drink? Explain.
6. State reasons why your local water supply system does not provide you with distilled water.
7. Describe the processes of purification that you think will be required for water that is taken from a creek or river.
8. Why is soft water needed in the paper and textile industries?
9. What methods can be used in desalting ocean water?

Test Yourself

Supply the word or words needed to complete each of the following statements.

1. The composition of water by volume is _____ parts _____ and _____ parts _____.
2. Since many substances dissolve in water, this compound is known as the _____.
3. When water passes through layers of sand and gravel, it is being _____ by the process of _____.
4. Water that does not lather easily is called _____.
5. Borax is often added to laundry water in order to _____.

Select the item that best completes the following statements.

1. Water can be decomposed into hydrogen and oxygen by (a) freezing, (b) boiling, (c) coagulating, (d) electrolyzing.
2. The chemical used in the coagulation method of water purification is (a) alum, (b) chlorine, (c) ammonia, (d) silver compound.

3. Fresh rain water is known as (a) hard water, (b) filtered water, (c) soft water, (d) demineralized water.
4. Aeration helps to purify water by (a) removing dissolved matter, (b) killing germs, (c) removing suspended particles, (d) all of these.
5. Suspended matter may be removed from water by (a) aeration, (b) filtration, (c) chlormation, (d) flatation.
6. If distilled water for a storage gallery cannot be obtained readily, the most satisfactory substitute would be (a) rain water, (b) well water, (c) lake water, (d) tap water.
7. Hard water is unsuited for washing purposes because it contains dissolved compounds of (a) sodium, (b) oxygen, (c) calcium, (d) hydrogen.
8. Hard water is usually softened by (a) employing the permutt process, (b) boiling, (c) filtering, (d) chlorination.
9. Distilled water is ordinarily used for (a) preparing medical prescriptions, (b) drinking, (c) laundering, (d) making carbonated beverages.
10. The percent of water in the human body is about (a) 30, (b) 50, (c) 70, (d) 90 percent.
11. The relative volumes of hydrogen and oxygen obtained by the electrolysis of water are (a) 1 to 2, (b) 2 to 1, (c) 1 to 8, (d) 8 to 1.
12. A process that is not part of the water cycle is (a) decomposition, (b) evaporation, (c) circulation, (d) condensation.
13. Sedimentation is a process of water purification that removes chiefly (a) bacteria, (b) dissolved impurities, (c) unpleasant odors, (d) suspended solid matter.

CROSSWORD PUZZLE EXERCISE

ACROSS

- 2 Properties such as color, density and melting points
- 7 Type of solution with much material dissolved in small amount of water
- 9 The type of bonding when water molecules attach to each other
- 10 The evaporation of water from the ocean, the water condensing into rain inland and then returning to the ocean
- 12 Name for water that has the impurities removed by ion exchange column
- 14 Will not dissolve in a liquid
- 16 A solution with a very small amount of dissolved solids
- 19 An aluminum salt used in water treating (coagulation) process
- 21 Deposit remaining on the inside of boiler when hard water is used to make steam (two words)
- 22 The type of solution where no more material will dissolve at a given temperature
- 24 The process of finely divided particles in suspension collecting into larger particles and settling rapidly
- 27 Difficult to make suds with
- 28 A state of matter with lowest density
- 30 An element that makes up one part of the water molecule
- 31 A liquid that is a part of a solution that dissolves the solid
- 35 The most natural state of water
- 36 Capable of being dissolved in water
- 37 Because opposite ends of the water molecule has different charges, it is said to be _____
- 38 Spraying water into the air like a huge fountain
- 39 Type of water taken from a faucet
- 40 Part of a solution that is dissolved
- 41 Water in which it is easy to make suds (two words)
- 42 The universal solvent

DOWN

- 1 Water that is free of contamination
- 3 Used to kill bacteria in water
- 4 The process of insoluble material formed on the bottom of water tanks in water purification
- 5 A name given to describe good drinking water
- 6 A liquid when it is not holding all solute possible
- 8 Weight per unit volume
- 9 The elements that make up two parts of the water molecule
- 11 The type of change that takes place with the electrolysis of water
- 13 Process of purification of water by vaporization and condensation
- 15 Common temperature scale used in the home
- 17 Water softening is done in the home by the _____ process
- 18 The element that causes most water hardness
- 20 Soluble impurities picked up by water from the soil
- 23 As water changes from steam to a liquid state
- 25 Water changing from liquid to solid by removal of heat
- 26 A physical property of water when it is crystal clear
- 32 A device made primarily of sand to make water crystal clear
- 33 State of matter of ice
- 34 Gaseous form of water

SUGGESTED WORD LIST FOR CROSSWORD PUZZLE

Water

Pure

Solvent

Fahrenheit

Colorless

Density

Polar

Distillation

Boiler Scale

Hydrogen Bond

Suspension

Chlorination

Sedimentation

Hard

Soft

Filter

Oxygen

Hydrogen

Calcium

Dilute

Concentrated

Tap

Freezing

Liquid

Boiling

Demineralized

Water cycle

Chemical

Physical

Coagulation

Alum

Chlorine

Aeration

Solute

Solvent

Potable

Permutt

Minerals

Demineralized

Insoluble

Soluble

Saturated

Unsaturated

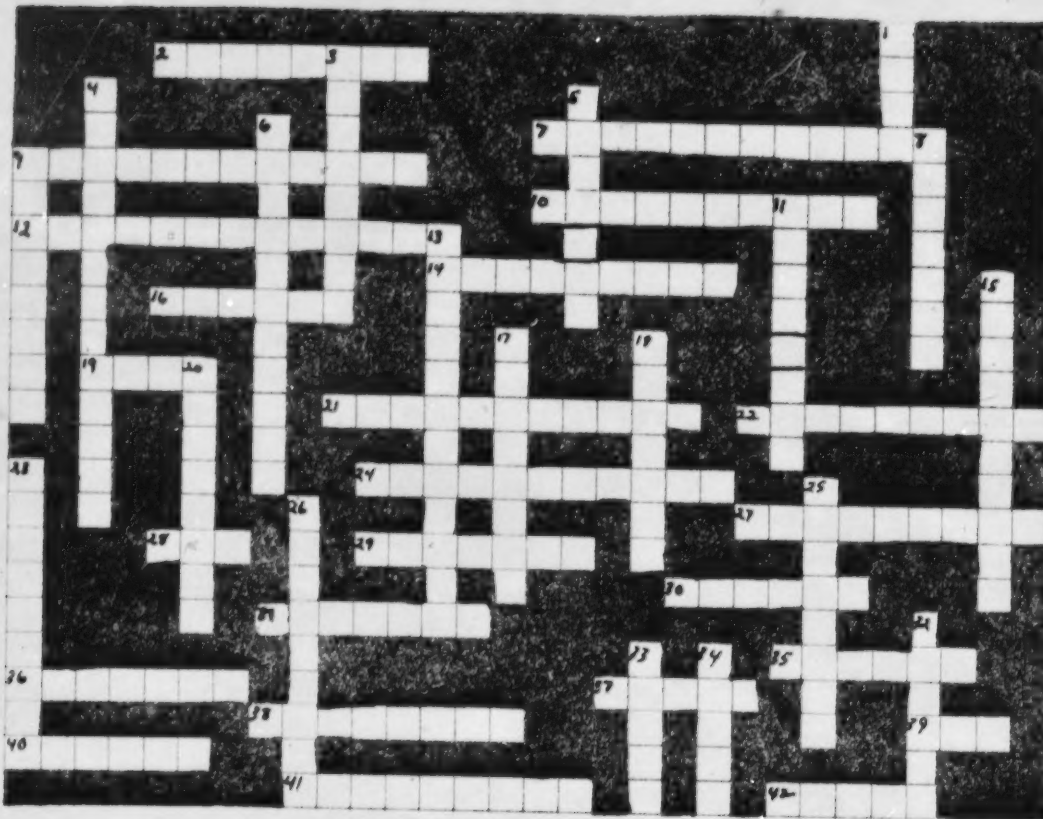
Vapor

Solid

Gas

Condenses

CROSSWORD PUZZLE



TEACHER SECTION

OBJECTIVES

The student will be able to:

1. describe the chemical composition of water.
2. identify the elements that make up pure water.
3. describe how burning certain substances can produce water.
4. describe some common physical properties of water.
5. relate physical properties of evaporation and condensation to the water cycle.
6. describe how water reaches its greatest density at 4°C .
7. describe why water is a polar molecule.
8. describe why water is a good solvent.
9. list and illustrate by example the factors that affect solubility.
10. demonstrate a concentrated and a dilute solution.
11. describe ways that common impurities in water can be detected and identified.
12. demonstrate a method of measuring the relative hardness of different sources of water.
13. explain why the presence of ammonia might indicate organic matter contamination.
14. describe methods that can be used for making water suitable for drinking.
15. describe your present water supply, and tell the purification steps used.

NOTES ON ACTIVITIES

a. Lab - Electrolysis of Water

Materials needed: Electrolysis Apparatus (Hoffman type), source of direct current, Bunsen burner, ring stand, clamp connecting wires, sulfuric acid making mixture 1:20, wood splint

CAUTION - Sulfuric acid is a very strong acid.

Student use Worksheet #1.

b. Lab - Water is a Product of Burning

Materials needed: candle, alcohol lamp, Bunsen burner, mirror or glass plate, charcoal, wood splints

c. Lab - Demonstrating the Water Cycle

Materials needed: 400 ml beaker, 500 ml round-bottomed flask, source of hot water

d. Demonstrating some Characteristics of Solutions

Materials needed: test tubes, potassium permanganate, salt, baking soda, sugar, Epsom salt

e. Lab - Factors Affecting Solubility

Materials needed: copper sulfate, mortar, 2 beakers (250 ml)

f. Lab - How can impurities such as chlorine, sulfates and organic matter be detected?

Materials needed (per set up): 3 test tubes (18 x 200 mm), litmus paper, ammonium hydroxide, silver nitrate solution (1%), calcium sulfate, sodium chloride, barium chloride solution (15%), soap powder, Borax, acetic acid (30%), ammonium oxalate solution (4%), Nessler's Reagent, 10 ml graduate cylinder, medicine dropper, potassium permanganate (.2 molar or 3.2 g per 100 ml H₂O), sulfuric acid

For the impure water used in this experiment, make it by adding a tablespoon full of salt (NaCl), calcium sulfate (CaSO₄) and ammonium hydroxide to a gallon of tap water.

CAUTION: The chemicals used in this activity are very corrosive. Handle with care. If they come in contact with skin or clothing, wash with tap water.

g. Lab - Test for Water Hardness

Materials needed: baby food jars with covers, liquid soap, Isopropyl alcohol, medicine droppers, distilled H₂O

A standard soap solution can be made by mixing liquid soap and Isopropyl 1 to 1.

Hard water can be made by adding a tablespoon full of calcium or magnesium sulfate to a gallon of tap water.

h. Lab - Measurement of the pH Value of Water

Materials needed: toothpicks, pHdriion paper (range 6-8 preferred)

The kit used for measuring the pH of the water in a tropical fish tank may be used. It contains an indicator Bromthymol blue (pH 6.0 to 7.8) and a color comparison chart, and it is available at Woolworth's or Peoples Drug Store for about 89c.

i. Lab - How Acid is the Rain?

Materials needed: pHdrion paper

j. Lab - Coagulation and Sedimentation

Materials needed: 2-400 ml beakers or 250 ml graduated cylinders, clay soil or Kaolin, lime (CaO), alum $\text{Al}_2(\text{SO}_4)_3$

Have students save this clarified settled water for next activity on filtration.

k. Lab - Filtration

Materials needed: approximately 7" plastic or glass funnel, sand, stone ($\frac{1}{2}$ " diam.), stone ($\frac{1}{4}$ " diam.), rubber tube, pinch clamp, ring stand with 4" ring clamp

Have students save sample of crystal clear water for next activity on chlorination.

l. Experiment - Chlorination

Materials needed: Chlorox or some chlorine releasing product

m. Experiment - Deodorizing with Activated Carbon

Materials needed: activated carbon, iron sulfide, hydrochloric acid, test tube, one-hole rubber stopper, glass tube, rubber hose

Assemble gas generator tube as shown in drawing.

Place small lump of iron sulfide and HCl acid in gas generating tube. The H_2S gas generated added to tap water in a gallon jug is the solution to be deodorized.

n. Lab - Purification of Water by Distillation

Materials needed: 500 ml distillation flask, condenser, 2 iron clamps, 2 ring stands, thermometer, wire gauze, rubber tubing for condenser, 100 ml beaker, two watch glasses, gas burner, copper sulfate

o. Lab - Purification of Water by Ion Exchange

Materials needed: Kleen Stream Water Filter (ion exchange demineralizer) for steam irons and batteries, available at Peoples Drug Store, approximate cost \$1.29. Instructions for use on kit.

KEY TO CROSSWORD PUZZLE

ACROSS

- 2 Physical
- 7 Concentrated
- 9 Hydrogen
- 10 Water cycle
- 12 Demineralized
- 14 Insoluble
- 16 Dilute
- 19 Alum
- 21 Boiler Scale
- 22 Saturated
- 24 Coagulation
- 27 Hard water
- 28 Gas
- 30 Oxygen
- 31 Solvent
- 35 Liquid
- 36 Soluble
- 37 Polar
- 38 Aeration
- 39 Tap
- 40 Solute
- 41 Soft water
- 42 Water

DOWN

- 1 Pure
- 3 Chlorine
- 4 Sedimentation
- 5 Potable
- 6 Unsaturated
- 8 Density
- 9 Hydrogen
- 11 Chemical
- 13 Distillation
- 15 Fahrenheit
- 17 Permitt
- 18 Calcium
- 20 Minerals
- 23 Condenses
- 25 Freezing
- 26 Colorless
- 32 Filter
- 33 Solid
- 34 Vapor

AUDIO-VISUAL AIDS

Available from Instructional Materials Center

1. Film 239 - Chemistry of Water
2. Film 874 - A Town that Washes its Water

RESOURCES

Instructional

1. Physical Science, Exploring the New World of Science by Lemkin, Oxford Book Company, 1969
2. Modern Physical Science by Tracy, Tropp, Friedl, Holt, Rinehart & Winston, Inc.
3. Laboratory Investigations for Modern Physical Science, Richard Gerfin, Holt, Rinehart & Winston, Inc., 1974
4. Environmental Pollution, Weaver, Holt, Rinehart & Winston, Inc., 1971
5. Exercises and Investigations for Modern Physical Science, Friedl, Holt, Rinehart & Winston, Inc., 1974

Reference

1. Current Science, Volume 59, Number 14, January 9, 1974, Xerox Education Publications
2. Water Pollution - Causes and Cures, Manufacturing Chemists Association (up to 10 copies FREE)
3. Everyday Facts about Good Water, Manufacturing Chemists Association, 1825 Connecticut Avenue, Washington, D.C. 20009 (up to 10 copies FREE)

Evaluation Form for Teachers

Name of mini-course _____

Evaluation Questions	Yes	No	Comments
1. Did this unit accomplish its objectives with your students?			
2. Did you add any of your own activities? If so, please include with the return of this form.			
3. Did you add any films that other teachers would find useful? Please mention source.			
4. Were the student instructions clear?			
5. Was there enough information in the teacher's section?			
6. Do you plan to use this unit again?			

7. Which level of student used this unit? _____

8. How did you use this unit - class, small group, individual? _____

PLEASE RETURN TO SCIENCE SUPERVISOR'S OFFICE AS SOON AS YOU COMPLETE THE COURSE.

SCIENCE MINI-COURSES

PHYSICAL SCIENCE

Prepared by

ELECTRICITY: Part 1
(Types of Generation of Electricity)

Marvin Blickenstaff

ELECTRICITY: Part 2
(The Control and Measurement of Electricity)

Marvin Blickenstaff

ELECTRICITY: Part 3
(Applications for Electricity)

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CAN YOU HEAR MY VIBES?
(A Mini-course on Sound)

Charles Buffington

LENSES AND THEIR USES

Beverly Stonestreet

WHAT IS IT?
Identification of an Unknown Chemical Substance

Jane Tritt

BIOLOGY

A VERY COMPLEX MOLECULE:
D.N.A. The Substance that Carries Heredity

Paul Cook

Controlling the CODE OF LIFE

Paul Cook

Paleo Biology - BONES: Clues to Mankind's Past

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A Field Study in HUMAN ECOLOGY

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